Price discovery in the Tanker Future Market, a survey on the IMAREX Tanker Derivative.

By

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Preface:

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All remaining errors are the responsibility of the author.

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Abstract

This paper examines the tanker freight future traded on Imarex, and to which degree these are found to discover future spot prices. This is done through testing the forward rate unbiasedness hypothesis and the lead lag relationship between future and spot contracts.
In all modelling the framework of cointegration and the Johannsen VECM approach is applied. All model estimation has been done in STAT 9.0, and E-views 5.1.
Results from Granger causality tests and Impulse response analysis find that there is evidence that the future contract discovers new information faster then the spot contract, and that pricing mechanisms in the futures market are better at reacting correctly to shocks both in future and spot prices. However no evidence of the future being an unbiased predictor of future levels of spot price is found.

Table of contents:

Introduction:

The introduction of the forward freight contract some two decades ago, gave producers as well as consumers of freight the opportunity to lock in their revenue or their costs prior to the time they should have acted in the spot market. These contracts are priced on the basis of the buyer's and seller's expectations of the future level of the price of freight.

The forward contract soon developed into a future on a weighted average of freight prices, which in the beginning of 2000 developed into a route specific freight future.

The existence of the future contracts serves several purposes; one of them is making parties in the underlying market able to hedge against unforeseen events. Another important feature is that it reflects the aggregated opinion of where the spot price will lie in the future, this feature is referred to as price discovery, (Working ,1970). This is an important exploit that gives traders of the underlying commodity as well as traders in related markets, a glimpse of what they should expect of the development of the commodities' price. How well the future market predicts the spot price greatly vary between both contracts and markets.

The scope of this paper is to determine if the tanker FFA's,(Forward freight agreement) traded on Imarex are fulfilling their role as price discoverers. This will be done by first testing if the tank future can be said to be a long run unbiased predictor of the future spot price, and secondly by studying the short run lead lag relationship between future and spot prices.

To examine whether the future gives a good indication of the future spot prices, one can statistically test the hypothesis of there being a 1 to 1 relationship between today's future and tomorrows spot. Although the relationship between the future and the spot has been studied in this aspect since the late 70's not many researchers have yet heeded the forward/futures market for freight. One obvious reason for this would of course be the unavailability of data, or, in comparison to other futures markets, the market for freight futures' lack of liquidity.

One of the few studies made on the lead lag relationship of the freight market has been conducted by Kavussanos et.al. (2004) on the OTC forward market for Atlantic and Pacific dry bulk freight contracts**.** They found evidence that for contracts one and two months before maturity, the future price is an unbiased predictor of the future spot price. Contracts three months before maturity Panamax Pacific routes are found to be unbiased predictors, while Panamax Atlantic routes are biased predictors of the future spot rate, concluding that the

validity of the unbiasedness hypothesis depends on time to maturity, the particular market, and the selected trading route.
Similar studies have been undertaken on currency exchange markets by amongst others Phillips & McFarland(1997). They test the unbiasedness hypothesis on the exchange rate between the Australian and the American Dollar. Here they estimate two different model specification, and find that the question posed by the unbiasedness hypothesis is somewhat dependent on the type structure of the model estimated.
Hakkio and Rush (1989), Barnhart and Szakmary (1991) and Mcnown and Wallace (1999) are amongst the many others who have studied the market unbiased predictors on the currency exchange rate. The first two studies found evidence against unbiasedness, while the last study found evidence supporting the hypothesis. It is apparent that one can not make any presumptions on how well the future course of different markets predicts the spot rate.
Though it seems that the closer the future contract is to expiry, the higher is the probability that it can be classified as an unbiased predictor of the spot. This result is somewhat intuitive; it is easier to predict the future when you are close to it. However the question of which method of modelling is to be applied to find the correct measurement of the future rates predictive power is a more technical question which might not be as easily decided upon.

My motivation for focusing my master's thesis on these markets is firstly that to my knowledge, no such work has been done on the tanker Freight Futures market. Interest for the FFA has grown, so has liquidity of the market, this in combination with the data of a future market being more homogenous then the data of a forward market should add to the predicative power of the contracts compared to what has been found by Kavussanos et. al.

The futures contract:

There are many ways to hedge against the time varying price risk of a commodity. The most obvious one is to buy what you need today, and store it until you will need it. This might work if the commodity in question is a box of strawberries but will be followed by big costs if we talk about 200kT of crude oil.
Thus instead of buying the commodity, today and store it for 6 months, you can draw up a contract with a counterpart taking the opposite position, where you concur to exchange an

agreed upon amount of some commodity, or financial paper, for an agreed upon amount of money on a future date. This contract is called a forward contract. The future contract is similar to the forward in principle. But it inherits some properties which makes it a more appealing derivative then the forward. Instead of being a contract where the buyer and seller agree on a price and a lot at a certain time, the future contract is a standardized contract, sold on an organized exchange. This makes it easier for the buyer, (seller), to find a party to take the opposite position. Another feature of the future contract is that it is cleared through a clearing house, hence eliminating all default credit risk.

The general description of the relationship between the spot and the future price is in Hull, J.C, (2006) given by;

$$F_{t|T} = S_T e^{(r-c+g)(T-t)} \quad (1.0)$$

, where F is future price, S is spot price, subscript t is the time today, T is the settlement day, r is risk free interest rate, c is convenience yield[1],and g is storing costs. This relationship is sometimes called the cost of carry, (Coc), and tells us that the future price should be equal to the discounted expected spot price. For any storable good the opportunity for arbitrage arises as soon as this relationship is broken. If the future is more expensive one can short the future and buy the spot, and vice versa.

As freight is a non storable commodity, i.e. it is impossible to buy freight today, and use it in half a year, the arbitrage opportunity upon which the cost of carry is based no longer holds. This attribute makes the market for freight along with some other derivative markets for non storable goods, such as the electricity market, and the market for weather derivatives, interesting subjects for study. For all these markets an obvious question to pose is if the lack of apparent arbitrage opportunities makes the predictive power of the future contract weaker then its equivalent on storable commodities.

[1] Convenience yield is the value of already having the commodity, as opposed to being able to buy it in the market at a later stage, i.e. delivery time might be shorter, no risk of not being able to get hold of the goods etc.

A short history of the freight future:

The first regular future contract for freight was a contract offered at Baltic International Freight Future Exchange (BIFFEX), a market based in London. A contract for dry-bulk was launched in 1985, and a year later a tanker contract was also launched, soon again to be removed due to lack of market interest. The contract traded on BIFFEX was a weighted average of the most heavily trafficked dry routes of the world. The weighing was based on the Baltic Freight Index, (BFI). This structure gave hedgers the possibility to remove some, but far from all the risk they where exposed to through the freight market. Trade in the Dry-bulk contract subsided towards the end of the century, and in April 2002 the market was closed due to lack of liquidity. Some, (Kavussanos & Nomikos, 2002)and, (Haralambides, 1993) have argued that the demise of the BIFFEX future came as a result of competition from the route specific Forward Freight Agreement, the FFA. This contract has existed alongside the BIFFEX contract, in OTC[2] markets.

In 2000 the OSLO based freight derivatives market IMAREX was launched, and in 2001 this became the first regulated market for route specific, cleared freight futures. The Imarex tanker future was introduced in October 2002. After a sluggish start the interest started growing in 2003, and has grown since, thus enhancing liquidity.

Contract structure:

The FFA traded on IMAREX is cleared through the Norwegian Futures and Options Clearing-house, (NOS), consequently eliminating all credit risk for both parties. Contracts traded on the market are one, two and three months ahead of delivery, the settlement date is the last day of the corresponding month. The contracts rollover[3] on the 20^{th}, or in case of the 20^{th} being a non trading day, the first subsequent trading day. The contracts traded on IMAREX should, strictly speaking, be defined as swaps, as the settlement price is set by the

[2] OTC is short for Over The Counter, and is the term used for non cleared contract which are privately negotiated, not traded on a market.

[3] There are always a set number of contracts on the market, as contracts close in on their settlement day, they are taken out of the market, when this happens a new contract is introduced, this mechanism is called rollover.

average spot price of the given route, the same month the contract expires.[4] Four quarterly contracts are also traded, with rollover the last day of the first month in the quarter. For this contract the underlying is the average of the three monthly rates. These, as well as annual and OTC contracts, will not be regarded in the following.

The future closing prices are obtained from Imarex and the spot prices from Baltic's of London. My data run from the 1st of October 2001 through 6th of September 2006 for routes TD3 TD5 and TD7[5]. For TC2 the data run from 12th February 2004 through 6th of September 2006, the reason being that this route was not introduced for trade before the 12th of February 2004.

The price of the contracts are reported in World Scale, (WS), points, an index based pricing system. The world scale price is based on assumptions regarding fuel costs, port costs, turnaround time etc. These assumptions are updated 1st of January every year. At this time the price of the index is set for every route. The WS points represent how many percent of the world scale price the price of the future is, i.e. 100WS equals 100% of the World Scale flat rate. The flat rate is set to represent what the World Scale Association believes to be the right price of freight under normal circumstances for the specific route and ship size.

As most other futures, the FFA does not deliver the underlying when it matures, but rather the monetary equivalent of the underlying, through daily market to market margin calls.

[4] The reason for the contracts being swaps is that there is not enough liquidity for daily or weekly contracts to be traded, hence the swap will give a better general hedge, than a contract settling on the spot a given day of the month

[5] TD is short for Tanker Dirty, indicating that the contract is on transportation of unrefined oil products. TC is in contrast short for Tanker Clean, indicating transportation of refined oil products.

The data:

I have chosen 4 tanker routes to focus on through the rest of the paper; these are chosen on the basis of being the most liquid tanker contracts traded. These contracts and their characteristics are represented in the table below.

Table 1.0:

Ticker	Trade Volume/Kt 01.04-09.06	Properties
TC2	11109.8	37,000mt, CPP/UNL Continent to USAC. Rotterdam to New York with laydays/cancelling 10/14 days in advance. Maximum age 15 years.
TD3	44160	260,000mt, Middle East Gulf to Japan. Ras Tanura to Chiba with laydays/cancelling 30/40 days in advance. Maximum age 15 years.
TD5	11950	130,000mt, West Africa to USAC. Off Shore Bonny to Philadelphia with laydays/cancelling 15/25 days in advance. Maximum age 20 years
TD7	15570	80,000mt, North Sea to Continent. Sullom Voe to Wilhelmshaven, with laydays/cancelling 7/14 days in advance. Maximum age 20 years.

In all estimations I will apply the natural log of the series. These values are graphed in the figures 2.1 -2.4 in the appendix.

As can be seen from the graphs the value of the contracts seems to peek around winter each year. An explanation for this can be that demand for energy rises in this period consequently so does the price for its transportation

As the contracts are settled the last of every month, the one month contract's time to maturity on the future will jump in connection with rollover every month. As one might expect time to maturity to affect the variance and consequently the price, I expect that some smoothing will be required.

There are to my knowledge, three ways of negating these jumps, one can pick out the contracts with a set amount of time to maturity, and regress on this data set. There is also the filtering opportunity, where a regression is run on the series, and the jumps in time to maturity are included as an exogenous variable. Any effect the jumps have on the price series can now be filtered out. A third way to encounter this problem is as suggested by Kavussanos & Nomikos (2003) to make a perpetual futures contract, consisting of the average of the last 22 prices of the contract. As the contracts already represent the 21-day average of the freight spot, this method would further smooth out the data set, taking away details from the spot and future series.

To check how big an impact the jumps in time to maturity have on the values of the future contracts I have run an ARIMA (3, 1, 0) (George Box and G. M. Jenkins, 1976), regression on the square of all future series. The reason for running a regression on the squares of the series is that this will find both the effect of jumps in time to maturity on price levels as well as on variance. Results of this regression can be found in table 2.2 in the appendix. On a 95% level of significance there is no indication that the jumps in time to maturity have an impact on the price series. As can be seen from the correlation matrix, (fig 2.0) there is a high level of correlation between the one and two month future of the corresponding routes, this can to some degree explain why there seems to be little impact as one contract rolls over to another.

The spot prices acquired form Baltic's of London, are set in day-to-day value of freight, and priced in WS points. As the underlying of the futures contract is the average spot of the month, I have had to create the underlying from the spot values. I found 21 to be the average amount of trading days in a month for my data set, so a series for the spot represented by the average of the 21 last trading days was created[6].

An important property of many financial time series is that they often prove to be non-stationary. Because this property is decisive for which methods can be applied in regressing on the series, it is important to evaluate the data in this aspect prior to any estimation. A stationary series has the property that a shock will diminish over time. In contrast, if a shock appears in a non stationary series, the effect will never die away.

There are several tests which can be applied for testing the stationarity of a series. I will apply the Augmented Dicky-Fuller test,(ADF) (D.A. Dickey and W.A.Fuller, 1979) applying the Schwartz binominal information criterion, Schwarz (1978), as well as the Phillips-Perron test,(PP), (Phillips and Perron, 1988). For an excellent text on these tests look at J.D.Hamiltons "Time series Analysis", p506-530.

[6] I have tested the calculated spot prices against the price of the futures contract on zero days to maturity, and the test sets where >0.01 away from their true value, indicating a good fit between the generated spot and the actual underlying.

Table 1.1:

ADF Test: 4 lags	Test Statistic	1 % critical value	5 % critical value	10 % critical value
***TD3_Spot**	-0.162	-2,580	-1,950	-1,620
***TD3_1mnth.**	0.124	-2,580	-1,950	-1,620
***TD3_2mnth.**	0.059	-2,580	-1,950	-1,620
***TD5_Spot**	0.025	-2,580	-1,950	-1,620
***TD5_1mnth.**	0.227	-2,580	-1,950	-1,620
***TD5_2mnth.**	0.226	-2,580	-1,950	-1,620
***TD7_Spot**	-0.134	-2,580	-1,950	-1,620
***TD7_1mnth.**	-0.084	-2,580	-1,950	-1,620
***TD7_2mnth.**	0.006	-2,580	-1,950	-1,620
***TC2_Spot**	-0.315	-2,580	-1,950	-1,620
***TC2_1mnth.**	0.001	-2,580	-1,950	-1,620
***TD2_2mnth.**	-0.065	-2,580	-1,950	-1,620

*The null hypothesis of unit root cannot be rejected on a 5% level of significance.

Table 1.2:

PP Test: Newey West Lags = 7		Test Statistic	1 % critical value	5 % critical value	10 % critical value
***TD3_Spot**	Z(rho)	-0.057	-13,8	-8,1	-5,7
	Z(t)	-0.085	-2,58	-1,950	-1,620
***TD3_1mnth.**	Z(rho)	0.057	-13,8	-8,1	-5,7
	Z(t)	0.132	-2,58	-1,950	-1,620
***TD3_2mnth.**	Z(rho)	0.033	-13,8	-8,1	-5,7
	Z(t)	0.061	-2,58	-1,950	-1,620
***TD5_Spot**	Z(rho)	0.040	-13,8	-8,1	-5,7
	Z(t)	0.095	-2,58	-1,950	-1,620
***TD5_1mnth.**	Z(rho)	0.069	-13,8	-8,1	-5,7
	Z(t)	0.249	-2,58	-1,950	-1,620
***TD5_2mnth.**	Z(rho)	0.079	-13,8	-8,1	-5,7
	Z(t)	0.248	-2,58	-1,950	-1,620
***TD7_Spot**	Z(rho)	-0.011	-13,8	-8,1	-5,7
	Z(t)	-0.026	-2,58	-1,950	-1,620
***TD7_1mnth.**	Z(rho)	-0.021	-13,8	-8,1	-5,7
	Z(t)	-0.081	-2,58	-1,950	-1,620
***TD7_2mnth.**	Z(rho)	0.003	-13,8	-8,1	-5,7
	Z(t)	0.009	-2,58	-1,950	-1,620
***TC2_Spot**	Z(rho)	-0.066	-13,8	-8,1	-5,7
	Z(t)	-0.654	-2,58	-1,950	-1,620
***TC2_1mnth.**	Z(rho)	-0.025	-13,8	-8,1	-5,7
	Z(t)	-0.152	-2,58	-1,950	-1,620
***TD2_2mnth.**	Z(rho)	-0.053	-13,8	-8,1	-5,7
	Z(t)	-0.283	-2,58	-1,950	-1,620

*The null hypothesis of unit root cannot be rejected on a 5% level of significance.

As can be seen from the regression results, a unit root on a 5% level of significance has been found for all series.

There is no indication either that the jumps in time to maturity that due to the structure of the contracts appear the 20th every month have any effect on neither the level, nor variance of the future contract price series.

Methodology:

I will in the following discuss the methods I will apply in estimating the model, as well as the assumptions made for these methods to be applicable. The first stage of my work will be to determine to what degree the future contract is an unbiased predictor of the spot rate. This I will do through testing the forward rate unbiasedness hypothesis, (fruh). The second stage of my assessment will be to determine which of the markets are the most responsive to new information. This relationship has been examined on many future markets, and is referred to as the lead lag relationship. Due to the results from the unit root tests, the concept of cointegration will be applied in both cases. Acshe and Guttormsen, (2001), argue that the single equation error correction model (ECM) proposed by Engel and Granger (1987) rely on the assumption of exogenity of the explanatory variable, thus making it unsuitable for testing the existence of such a relationship. To avoid this problem the Johannsen (1988, 1991) framework of multivariate simultaneous equation estimation is suggested.

Unbiasedness hypothesis:

In theory, if one assumes that market participants are rational and perfectly informed, the future rate should be an unbiased predictor of the spot on the day or expiry. The problem in the real world is that participants in the futures market are not perfectly informed. Some information may be accessible to a select few, or arrive at different times to different traders; other information might be erroneous. Traders might not see information the same way, and the right way to see it might not be known until the future already has revealed itself. For these reasons it is sensible to be critical to the predictive power of the future contract.
A Model for the relationship between the future and the spot price of a non storable commodity can be given by:

$$F_{t|T} = E(P(t,T)) + E(S_T) \tag{2.0}$$

Here F is today's future price for a contract expiring at time T; E (P (t, T) is the expected risk premium, and E(S) is the expected spot price at time T. The risk premium is defined as a bias of the future price as a predictor of the future spot price, and must thus be equal to zero if the unbiased hypothesis is to hold.

To test this relationship statistically one could estimate the model;

$$F_{t|T} = \alpha(t) + \beta S_T + \varepsilon_t \tag{2.1}$$

Where S(T) is the spot at time T, a is the risk premium, b is to what degree the future price at t has discovered the spot at T, and F(t|T)equals the price of a future which expires on T and e is a white noise error term. It can be concluded that the future is an unbiased predictor of the spot if a=0 and b=1, if this is not the case, the hypothesis must be rejected.

As the future and spot series are found to be non-stationary, a straight forward OLS estimation of the above relationship has in many cases, (Cornell (1977), and Frenkel (1977, 1981)), been found to render results consistent with the forward rate unbiasedness hypothesis,(FRUH), but which are proven to be the result of a spurious regression, (Baillie and Bollerslev (1989)). Instead we can apply the concepts of cointegration initiated by Granger and Engel, (1987), and later developed by Johannsen (1988)[7].

If a time series must be differenced once to become stationary, the series is said to contain a unit root, and is denoted a series integrated of the first order. Any linear combination of two such series will also be I (1). It will be crucial for any model estimation that the spot and future are cointegrated. In principle this means that there exists some stationary linear relationship between the two series. To test if such a relationship exists, one can regress the one series on the other, and see if the residual terms from the regression contain a unit root through regular ADF or PP testing. Theoretically the relationship can be given by:

$$S_T - bF_{t|T} = \varepsilon_T \tag{2.2}$$

[7] For an applied guide to these methods visit http://econ.la.psu.edu/~hbierens/EasyRegTours/COINTJ.HTM.

If some value of b exists that makes the error term a stationary series, two series are said to be cointegrated. Through a cointegrating relationship we can estimate a set of equations which will be used to determine whether the unbiasedness hypothesis holds. For testing of the long run unbiasedness hypothesis through a cointegrated framework;

$$\Delta X_T = a + \Pi X_{T-k} + \varepsilon_t \qquad (3.0)$$

can be applied. Δ is the 1 difference operator, x is the (1*2) vector (S (T), F (T-k)), a is a constant, Π is the coefficient matrix, and έ is the error term.

The rank of Π determines how many cointagration relations there exist between the spot and the lagged future prices. If the series are cointegrated, Π can be factored into φβ', both φ and β being 1*2 vectors. β will here represent the cointegrating vector (1, B) and φ will contain the adjustment parameters.

Adding some restrictions on the constant term, a, the expanded representation;

$$\begin{aligned} \Delta S_t &= \varphi_s(F_{t-1} + \beta S_{t-1} + \alpha_s) + \varepsilon_t \\ \Delta F_t &= \varphi_f(F_{t-1} + \beta S_{t-1} + \alpha_f) + \varepsilon_t \end{aligned} \qquad (3.1)$$

is suggested by amongst other Bollerslev and Ballie (1989). This representation allows to test several implications of the Unbiasedness hypothesis, a) cointegration between S and F, b) β = -1, c) That there is no drift rate, ά=0 and d) if the above hold that the future price predicts the price movement of the spot through φ^s =1, (Guerra, 2002).

Lead Lag:

For any market of storable goods, arbitrage arguments show that there should be no short term lead-lag relationship between the future and the spot price. As the future as well as the spot market both represent the same underlying values, only differing in time of delivery, a breach of the cost of carry relationship will cause arbitrage opportunities to arise, which through trade will move prices back in equilibrium. This is of course a truth with modifications, factors such as transaction costs, market liquidity, difference in market perception, and availability of information will cause the two markets to sometimes move in different directions.

Many have researched the lead lag relationship between spot and future. , Kavussanos et al. (2002) found in their paper on the market for OTC Forward freight agreements, evidence of a bi directional relationship between spot and future market, with a tendency for the FFA to discover new information faster then the Spot. Silvapulle and Moosa (1999), have similar findings in their study of the crude oil market. Both parties argue that the observed phenomenon can be explained by difference in microstructure between the spot and future market, i.e. higher transaction costs, and more restrictions on short trading in the spot market, in combination with more adept market participants in the future market. On the other hand Moosa (1994) finds indications of a causal relationship going in the opposite direction in the crude oil market. Here the explanation is found to be that a change in spot prices triggers a series of transactions by different market participants, eventually resulting in a change in the future price.

In contrast to the spot market, traders in the market for FFAs are not only producers and consumer of freight, but also speculators and arbitrage traders. As mentioned above studies of other future markets find it plausible that the market is more attentive to new information then the physical market. A way to statistically test whether this hypothesis is correct or not is to look for a so called Granger Causal[8] relationship between the series. A series A is said to Granger cause series B if one can better predict future values of the series B by adding lagged values of series A in the regression equation.

A study on the lead lag relationship between the Biffex future and its underlying was conducted by Kavussanos and Nomikos (2003). They found as I have that both spot and future series contained a unit root. The Johannsen Cointegration Vector Error Correction Model ,(VECM), procedure was therefore successfully applied. Applying the Johannsen VECM specification makes it possible to test for Granger causality, as well as to estimate Impulse Response Functions, (IRFs) to better study the dynamic properties of the series in the presence of shocks.

The Johannsen VECM can on general form be represented as:

[8] What is meant by causality in this context is not that one series necessarily causes the other series, but rather that one series lead the other series.

$$\Delta X_t = \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \varepsilon_t \tag{4.0}$$

This is the same model as (3.0), in all respects except three, no constant is added to the model, Π is here the coefficient matrix for the relationship between current values of spot and future price as opposed to the relationship between current values of spot price and lagged values of future price as in (3.0) and allowance for lagged values of the first difference of spot and future prices to enter the model is also made. The Γ's are 2*2 matrixes measuring adjustments to the series from changes in X^t. The model can in expanded form be represented as:

$$\begin{aligned} \Delta S_t &= \sum_{i=1}^{p-1} a_{S|i} \Delta S_{t-i} + \sum_{i=1}^{p-1} b_{S|i} \Delta F_{t-i} + \alpha_S z_{t-1} + \varepsilon_{S|t} \\ \Delta F_t &= \sum_{i=1}^{p-1} a_{F|i} \Delta S_{t-i} + \sum_{i=1}^{p-1} b_{F|i} \Delta F_{t-i} + \alpha_F z_{t-1} + \varepsilon_{F|t} \end{aligned} \tag{4.1}$$

Here Δ is as in (3.0, p. 11) the first difference operator, a, b, and α are adjustment parameters e is a white noise error term and z gives the error correction terme BX' where B is the cointegrating vector (1,B), and X is the vector (S, F). If there is a cointegrating relationship between two time-series, causality must exist in at least one direction. To determine the number of lags to include in the modelling Akaike, (AIC), (Akaike (1974)), Hannan Quinn (HQIC), (Hannan, E. J., and B. G. Quinn (1979)), and Schwartz , (SBIC) (Schwarz (1978)), information criterion will be applied. The question if there exists a Granger causal relationship between the two series will then be determined from estimating the model. If any of the coefficients a^F or b^S are found to be significantly different from 0, a lead lag relationship is determined.

Now the specification for testing both the long run unbiased hypothesis and the short run lead lag relationship between spot and future prices has been decided. Due to evidence of both series containing a unit root, the Johannsen VECM approach will be applied.

Empirical evidence:

As mentioned a fundamental step in this survey will be to determine if the future and the spot price is cointegrated. The existence of a cointegrating relationship between both today's spots and future contracts, (short run), and today's spot and lagged values of the future contracts, (long run) must be determined. It is argued by Guerra, (2002) that if the first difference of the spot and future is stationary, and there exists a (1, -1) cointegrating relationship between today's spot and future, the same cointegrating relationship must exist between current spot and lagged future price.

To test the fruh I have run Johannsen (1988, 1991), cointegration tests between lagged values of both 1 and 2 month futures on the spot. The VECM model specification of this estimation is equal to (3.1 p.11), i.e. I have included no lagged differences and one restricted constant in the model.

Table 2.0

	Hypothesis Trace Ho:	H1:	Test Statistic	5 % critical value
TD3_Spot-TD3_1mnth.	r = 0	r ≥ 1	48.3232	19.96
	r ≤ 1	r = 2	**7.8753***	9.42
TD3_Spot-TD3_2mnth.	r = 0	r ≥ 1	**18.3435***	19.96
	r ≤ 1	r = 2	5.3920	9.42
TD5_Spot-TD5_1mnth.	r = 0	r ≥ 1	42.0348	19.96
	r ≤ 1	r = 2	**6.6083***	9.42
TD5_Spot-TD5_2mnth.	r = 0	r ≥ 1	40.6996	19.96
	r ≤ 1	r = 2	11.3429	9.42
TD7_Spot-TD7_1mnth.	r = 0	r ≥ 1	41.8533	19.96
	r ≤ 1	r = 2	**8.5405***	9.42
TD7_Spot-TD7_2mnth.	r = 0	r ≥ 1	28.6919	19.96
	r ≤ 1	r = 2	10.8573	9.42
TC2_Spot-TC2_1mnth.	r = 0	r ≥ 1	50.0633	19.96
	r ≤ 1	r = 2	**2.9093***	9.42
TC2_Spot-TD2_2mnth.	r = 0	r ≥ 1	**10.0327***	19.96
	r ≤ 1	r = 2	1.2636	9.42

A restricted constant is added to the model, no lagged differences are included. The rank of the coefficient matrix determines the number of cointegrating relationships between spot and future series. * significant at a 5% level

Evidence from the cointegration tests show that there exist one cointegrating relationship between all 1 month future contracts and spot rates. For the 2 month future contracts there is no cointegrationg relationship between the TD5 and TD7 futures and the corresponding spot, while there exist infinitely many cointegrating relations between the TC2 and TD3 futures and spot contracts. Thus there is no stationary relationship between the 2 mnth future and spot, so any modelling of the relationship between the two series will be spurious, for the TD3 and TC2, 2 months futures the results form the cointegration test indicates that the series are indeed stationary, thus a linear regression could be done. This does not harmonize with the unit root tests, and might result in spurious regressions. For these reasons the testing of the long run FRUH will only be applied to 1 month contracts.

Table 2.1

$$\boxed{\Delta F_t = \varphi_f (S_{t-1} + \beta F_{t-1} + \alpha_f) + \varepsilon_t} \qquad \boxed{\Delta S_t = \varphi_s (S_{t-1} + \beta F_{t-1} + \alpha_s) + \varepsilon_t}$$

	φ	β	α	φ	β	α
TD3	0.0028425	-1.305204	1.374898	0.0210761	-1.305204	1.374898
SD	(0.0037351)	(0.1716379)	(0.7895747)	(0.0033088)	(0.1716379)	(0.7895747)
P-value	0.4470	0.0000	0.0820	0.0000	0.0000	0.0820
TD5	0.000002	-1.145481	0.6664909	0.0206431	-1.145481	0.6664909
SD	(0.0041791)	(0.1466758)	(0.7271037)	(0.0034484)	(0.1466758)	(0.7271037)
P-value	0.0258	0.0000	0.3590	0.0000	0.0000	0.3590
TD7	0.0026479	-1.27688	1.362262	0.0175305	-1.27688	1.362262
SD	(0.0037877)	(0.1872057)	(0.9438336)	(0.0030421)	(0.1872057)	(0.9438336)
P-value	0.4850	0.0000	0.1490	0.0000	0.0000	0.1490
TC2	-0.004207	-0.998845	-0.015101	0.051064	-0.998845	-0.015101
SD	(0.004081)	(0.0810347)	(0.4579903)	(0.0115786)	(0.0810347)	(0.4579903)
P-value	0.3030	0.0000	0.9740	0.0000	0.0000	0.9740

Regression coefficients from a Johannsen VECM maximum likelihood estimation of (3.1). In parenthesis are the standard deviations of the coefficients.

From the estimated equation (3.1,p.12) we can see that in addition to cointegration between future and spot, the betas of the cointegrating equation can not be said to be different from one on a 5% level of confidence, all the trend terms alpha are not significantly different from zero, so no bias in the form of a time varying risk premium is evident. The adjustment parameter phi are for the future to spot relationship all found to be significantly different from zero, indicating that the future has some predictive power on the spot, however the coefficient is far from one, which is the value it must have to satisfy the hypothesis.[9]. Thus it can be concluded that even though there seems to be no time varying risk premium on the

[9] It is worth mentioning that the value of the future to spot phi for TC2 is somewhat bigger than the phi's of the dirty routes, as the data set of the TC2 starts march 2004, this might indicate that the predictive power of future contracts have to some extent improved over the years.

future contract, the 1 month future contract cannot be said to be an unbiased predictor of the future spot rate. The lagged values of one and two month's future contracts are graphed in figure 1.0-1.4. Here the results from the regression analysis are obvious. There is little or no evidence of the future price predicting the spot price of freight for any of the routes.

Concerning the estimation of model (4.0), the short run relationship between spot and future, pre estimation lag order tests have been run on the data. Because of the frequency of the data, max lags to be included in the data are set to 16.

Table 3.0
Number of lags to be included in regression:

	AIC	HQIC	SBIC
TD3_Spot-TD3_1mnth.	6	2	2
TD3_Spot-TD3_2mnth.	8	2	2
TD5_Spot-TD5_1mnth.	9	2	2
TD5_Spot-TD5_2mnth.	5	2	2
TD7_Spot-TD7_1mnth.	6	3	2
TD7_Spot-TD7_2mnth.	6	4	2
TC2_Spot-TC2_1mnth.	16	9	9
TC2_Spot-TD2_2mnth.	13	9	9

For both TD3 and TD5 there seems to be a trend that the 3 lag has very little explanatory power, thus both Schwartz binominal information criteria and Hannan-Quinn Information Criterion, decide that the maximum number of lags is limited to 2. Some of the dynamics of the two price series will be lost if no more than two lags are included, I will therefore apply the somewhat weaker Akaike information criteria, when deciding upon how many lags to include in the model.

Testing for cointegration between the future and the spot rate will be done applying the Johannsen cointegration test as above. Number of lagged differences to include in the test will be determined by the AIC.

Tabell 3.1

	Hypothesisi Trace		Test Statistic	5 % critical value
	Ho:	H1:		
TD3_Spot-TD3_1mnth.	r = 0	r ≥ 1	27.1696	12.53
	r ≤ 1	r = 2	**0.0214***	3.84
TD3_ Spot-TD3_2mnth.	r = 0	r ≥ 1	46.4754	12.53
	r ≤ 1	r = 2	**0.0235***	3.84
TD5_Spot-TD5_1mnth.	r = 0	r ≥ 1	19.1847	12.53
	r ≤ 1	r = 2	**0.0813***	3.84
TD5_Spot-TD5_2mnth.	r = 0	r ≥ 1	41.8165	12.53
	r ≤ 1	r = 2	**0.0293***	3.84
TD7_Spot-TD7_1mnth.	r = 0	r ≥ 1	27.5832	12.53
	r ≤ 1	r = 2	**0.0139***	3.84
TD7_Spot-TD7_2mnth.	r = 0	r ≥ 1	61.7083	12.53
	r ≤ 1	r = 2	**0.0003***	3.84
TC2_Spot-TC2_1mnth.	r = 0	r ≥ 1	**3.2452***	12.53
	r ≤ 1	r = 2	0.0029	3.84
TC2_Spot-TD2_2mnth.	r = 0	r ≥ 1	**3.2152***	12.53
	r ≤ 1	r = 2	0.0046	3.84

Lagged differences included in estimation of the model are in accordance to the AIC. No constant or trend is added to the model. The rank of the coefficient matrix determines the number of cointegrating relationships between spot and future series. * significant at a 5% level.

The result from testing the cointegrating rank of the VECM specified by (4.1), with lag order decided by AIC, shows that there exists one cointegrating relation between all futures and spots, with the exception of the contracts on TC2, where there in conflict with the results from the stationarity test, seems to be an unlimited amount of cointegrating relations indicating that the series are indeed stationary. Estimation of the VECM (4.1) will therefore be done on all three dirty routes, (TD3, TD5, and TD7).

From the regression results appendix table 4.0 we can find for the one month TD3 future seems to lead the spot price. Regarding the 2 month future on TD3, TD5 contracts and the 1 month TD7 there is a bi-directional relationship between spot and future where the future to spot relationship seem to be somewhat stronger than the spot to future relationship. There is also a bi-directional relationship between the 2 month TD7 and the spot, but here the influence of the series seems to be equally strong in both directions. To statistically test the Granger causal relationship I have also run an F-test on the joint significance of all cross sectional coefficients. The null hypothesis is that no Granger causal relation between the two series exists. If one series is found to have no significant impact on the other, the null hypothesis will not be rejected.

Tabell 3.2

Lags in all tests are equal to number of lags included in the VECM,

Null Hypothesis:	Obs	F-Statistic	Probability	
TD3_1 month does not Granger Cause TD3_Spot.	1369	**7.62654**	**4.5E-08**	**
TD3_Spot does not Granger Cause TD3_1 month.		0.81279	0.55992	
TD3_Spot does not Granger Cause TD3_2 month.	1367	**4.40514**	**2.8E-05**	**
TD3_2 month does not Granger Cause TD3_Spot.		**6.81890**	**8.3E-09**	**
TD5_1 month does not Granger Cause TD5_Spot.	1366	**8.08502**	**9.5E-12**	**
TD5_Spot does not Granger Cause TD5 1 month.		**2.26360**	**0.01630**	*
TD5_2 month. does not Granger Cause TD5_Spot.	1370	**12.8060**	**3.5E-12**	**
TD5_Spot does not Granger Cause TD5_2 month.		**11.0833**	**1.8E-10**	**
TD7_1mnth. does not Granger Cause TD7_Spot.	1369	**13.7783**	**3.0E-15**	**
TD7_Spot does not Granger Cause TD7_1 mnth.		**2.43811**	**0.02386**	*
TD7_2 month does not Granger Cause TD7_Spot.	1369	**10.5986**	**1.6E-11**	**
TD7_Spot does not Granger Cause TD7_2 month.		**6.84065**	**3.6E-07**	**

* The null hypothesis is rejected on a 5% level of significance, **the null hypothesis is rejected on a 1% level of significance.

We can see from the table that there seem to be a bi directional causal relationship between all spot and future price series, except for the 1 month TD3 where there is a singular future to spot relationship. The spot to future relationship on the one month TD5 and TD7 is not as significant as the future to spot relationship. As the power of the relationship is determined by the size of the coefficients and not only the significance of them, we can in general say that there is evidence for all routes that the future to spot relationship is stronger then the spot tu future relationship.

Impulse Response Functions (IRF's) has been estimated, and effects of a one standard deviation, (s.d.), shock in the series are represented in the figures below. The graphs show the time it takes the price series from a shock is introduced until steady state is reached. The horizon of the graphs is 500 days.

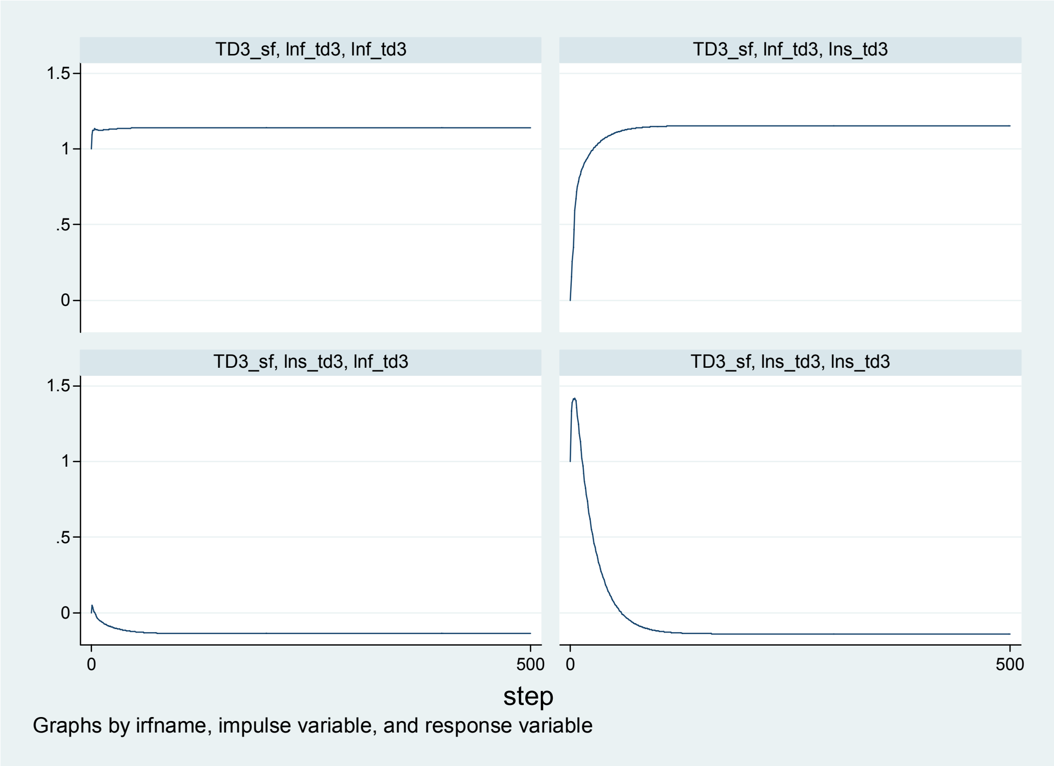

Figure I: RHS(right hand side), dynamics of the 1 month TD3 futures price as a 1 s.d. shock in the future, (above) and spot, (below) hits the series.
LHS (left hand side); dynamics of the TD3 spot as a 1 s.d. shock in the future (above) and spot (below) hits the series.

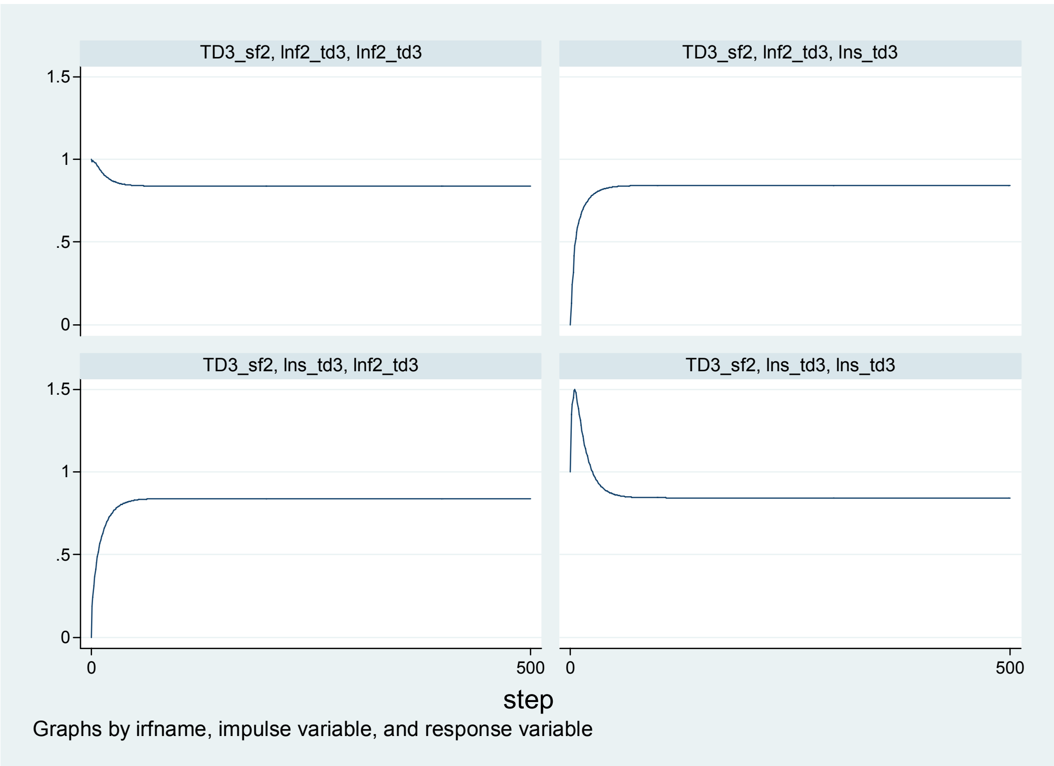

Figure II: RHS, dynamics of the 2 month TD3 futures price as a 1 s.d. shock in the future, (above) and spot, (below) hits the series. LHS, dynamics of the TD3 spot as a 1 s.d. shock in the future (above) and spot (below) hits the series.

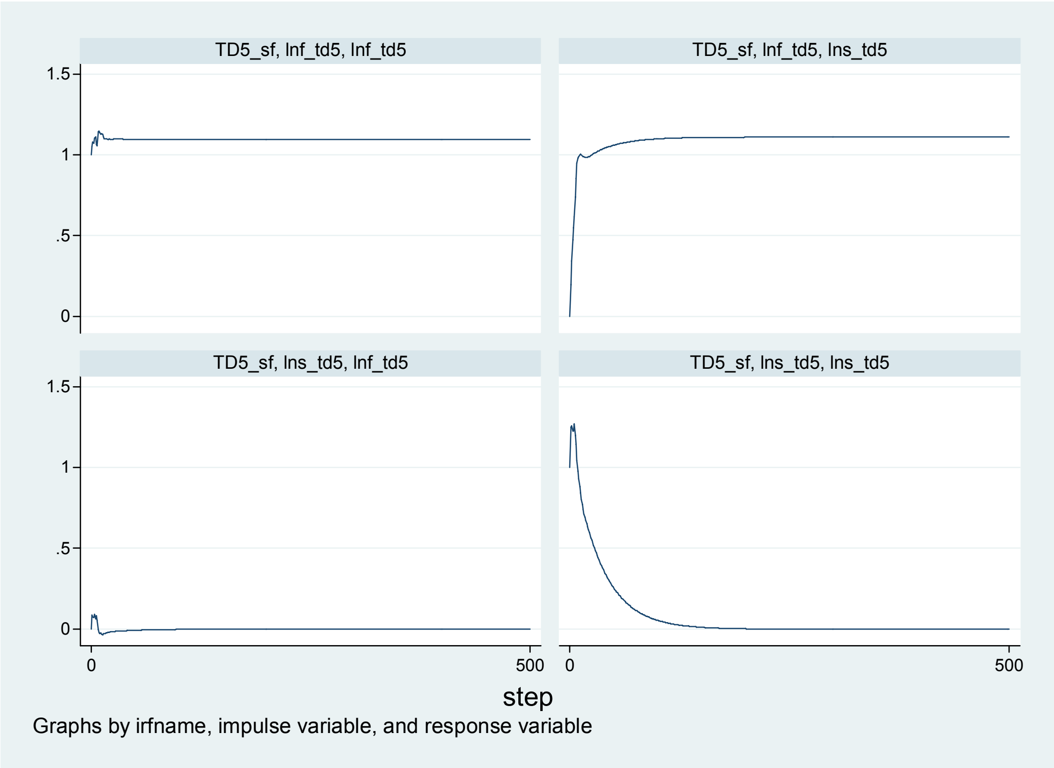

Figure III: RHS, dynamics of the 1 month TD5 futures price as a 1 s.d. shock in the future, (above) and spot, (below) hits the series. LHS, dynamics of the TD5 spot as a 1 s.d. shock in the future (above) and spot (below) hits the series

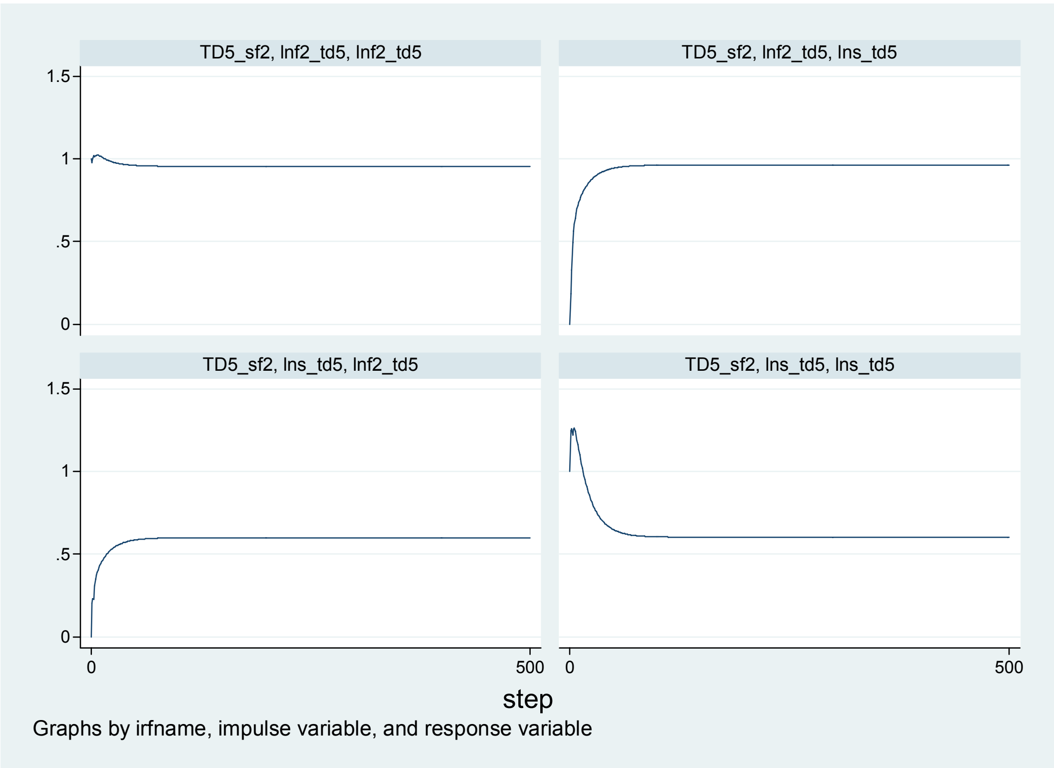

Figure IV: RHS, dynamics of the 2 month TD5 futures price as a 1 s.d. shock in the future, (above) and spot, (below) hits the series. LHS, dynamics of the TD5 spot as a 1 s.d. shock in the future (above) and spot (below) hits the series

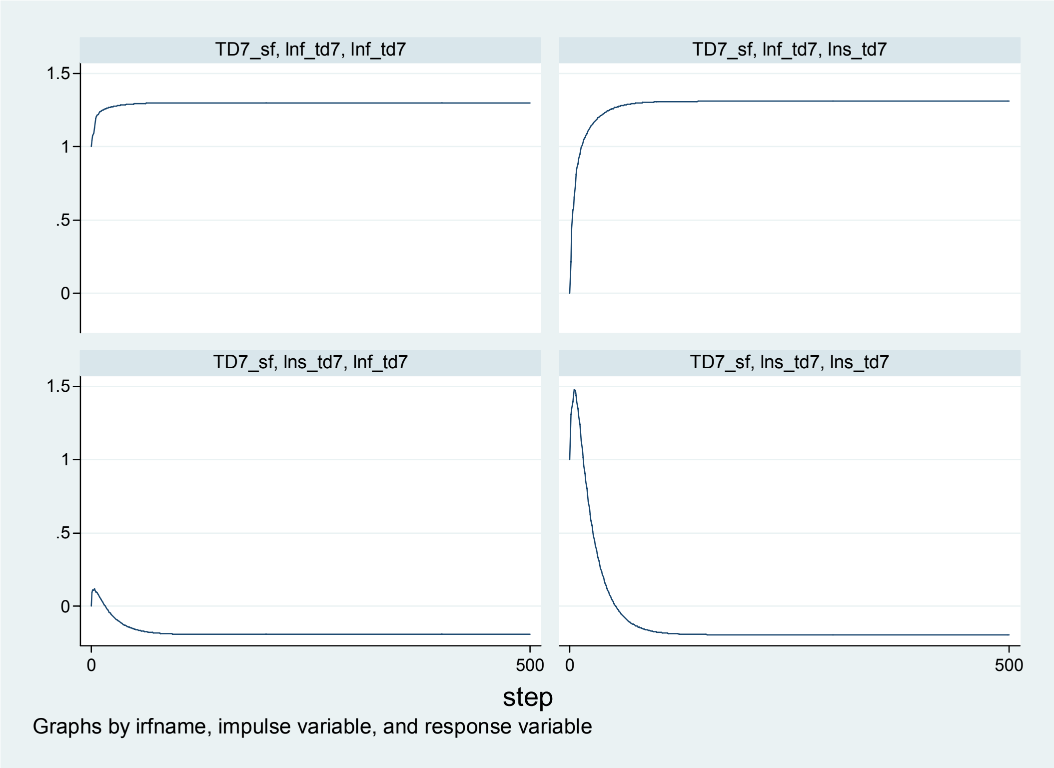

Figure V: RHS, dynamics of the 1 month TD7 futures price as a 1 s.d. shock in the future, (above) and spot, (below) hits the series. LHS, dynamics of the TD7 spot as a 1 s.d. shock in the future (above) and spot (below) hits the series

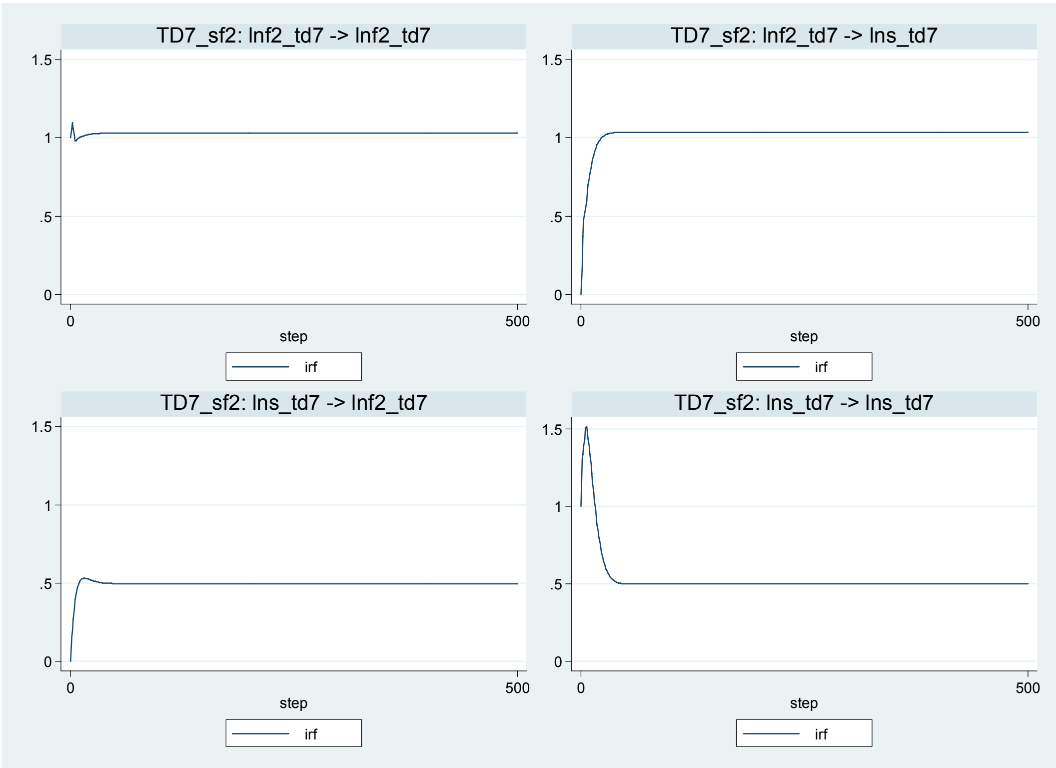

Figure VI: RHS, dynamics of the 2 month TD7 futures price as a 1 s.d. shock in the future, (above) and spot, (below) hits the series. LHS, dynamics of the TD7 spot as a 1 s.d. shock in the future (above) and spot (below) hits the series

From the IRFs figure I-VI we can see that there is a general trend that when a shock appears in the spot price the spot series has a tendency to overshoot the long run steady state. In the one and two month future contracts there seems to be little or no evidence of overshooting. Shocks in the future prices seem to result in neither the spot nor future price overshooting. It is also clear that the time it takes for the series to adjust to their steady state is quite different. For all series it is obvious that the effects of a shock are longer lived in the spot series. This is the case whether the shock originates in the future or spot series and can indicate that the mechanisms in the futures market which finds back to the long run price level works faster in the future market then what is the case for the spot market.

Conclusion:

In an efficient futures market for any storable goods one would expect to find the future price being an unbiased predictor of the spot price. This is due to arbitrage arguments such as the Coc, and the efficient market hypothesis. Due to the fact that the Coc is not applicable in the market for freight futures, thus leaving out market driving arbitrage mechanisms, one might expect that the future of freight would not be as good a predictor of the future spot as the future for any storable commodity. When examining the unbiasedness hypothesis on the one month futures contracts for tanker freight this seems to be the case. None of the contracts satisfy the conditions set by the unbiasedness hypothesis. Comparing my findings with similar results from the currency exchange market, (W A Razza, 1999), one could conclude that the Coc is an important catalyst for the predictive power of the futures market. But the absence of obvious arbitrage opportunities might not be the only reason for the future doing a somewhat poor job in predicting the future spot-price. As can be seen from figures 2.1-4, p. 33 the market for freight is particularly volatile market, thus making the job of predicting the future a difficult one. There is also the variable of market liquidity. The tanker derivative has been trading for approximately six years, and it is arguably still a young market. As is indicated by the results from testing of the unbiasedness hypothesis on the TC2 data, which started trading in the more liquid 2004 market, the increase in liquidity has had an impact on the predictive power on the future spot rates. One might expect that further predictive power will be gained as the market matures and liquidity improves.

On the other hand, it is evident from the short run analysis of the market that the pricing process of the futures market is faster to pick up new information, and responds to this information more correctly then does the spot market. This is obvious both from the impulse response analysis and from the model estimates, and might be due to the difference in microstructure of the two markets, (i.e. the possibility of short selling in the futures market,) and/or the difference in proficiency of participants of the markets. Liquidity is also in this case a factor to address, as the market for FFAs have out grown the physical market the latter years; one would expect that pricing mechanisms in this market also to surpass the spot markets.

Summing up, the FFA seems to some degree to fill its role as price discoverer on a day to day basis. The degree of price discovery seems to be related to the liquidity of the contract. On the longer term, the FFA cannot be said to discover future spot prices.

The implications of these results are that participants in the physical market can benefit from following the movement of the future prices more closely. At the presence of unexpected events there is evidence that the spot market could dispose of some price volatility, if pricing was more in accordance with future prices. There is no evidence that the future prices predicts future spot prices, indicating that participants in the spot market still have a lot of uncertainty to deal with. Thus one could expect the freight futures role as a hedging instrument will still be an important tool for physical players.

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Appendix:

Table 1.0: Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
TD3 Spot	953	4.63367	.431866	3.69883	5.83764
TD3 1 mnth. Future	953	4.58357	.360401	3.74950	5.73657
TD3 2 mnth. Future	953	4.60601	.396974	3.74950	5.76047
TD5 Spot	953	5.01148	.332408	4.24592	5.99094
TD5 1 mnth. Future	953	4.94562	.299800	4.28358	5.96614
TD5 2 mnth. Future	953	4.97335	.321786	4.31748	5.92692
TD7 Spot	953	5.06280	.301649	4.46014	5.80184
TD7 1 mnth. Future	953	5.03068	.244721	4.55387	5.80814
TD7 2 mnth. Future	953	5.04319	.265265	4.51085	5.79909
TC2 Spot	927	5.59167	.222916	5.00095	6.06836
TC2 1 mnth. Future	588	5.64626	.193565	5.30181	6.16331
TC2 2 mnth. Future	578	5.64750	.199008	5.29078	6.15273

Tabell 2.0: Variance covariance matrix

	TD3 spot	TD3 1 mnth	TD3 2 mnth	TD5 spot	TD5 1 mnth	TD5 2 mnth	TD7 spot	TD7 1 mnth	TD7 2 mnth	TC2 spot	TC2 1 mnth	TC2 2mnth
TD3 spot	1.000											
TD3 1 mnth	0.795	1.000										
TD3 2 mnth	0.916	**0.906**	1.000									
TD5 spot	0.766	0.763	0.816	1.000								
TD5 1 mnth	0.687	0.921	0.847	0.843	1.000							
TD5 2 mnth	0.734	0.854	0.867	0.930	**0.945**	1.000						
TD7 spot	0.622	0.557	0.624	0.774	0.625	0.703	1.000					
TD7 1 mnth	0.683	0.820	0.781	0.797	0.872	0.843	0.812	1.000				
TD7 2 mnth	0.667	0.696	0.734	0.846	0.776	0.843	0.923	**0.909**	1.000			
TC2 spot	0.203	0.380	0.333	0.329	0.420	0.403	0.226	0.256	0.262	1.000		
TC2 1 mnth	0.165	0.492	0.360	0.299	0.543	0.466	-0.006	0.234	0.137	0.293	1.000	
TC2 2mnth	0.160	0.487	0.354	0.294	0.537	0.461	-0.013	0.227	0.131	0.295	**1.000**	1.000

Here correlation coefficients between the natural log of the spot and natural log of current future prices are represented

Table 2.1 Variance covariance matrix (lagged values)

	TD3 spot	TD3 1 mnth	TD3 2 mnth	TD5 spot	TD5 1 mnth	TD5 2 mnth	TD7 spot	TD7 1 mnth	TD7 2 mnth	TC2 spot	TC2 1 mnth	TC2 2mnth
TD3 spot	1.000											
TD3 1 mnth	0.481	1.000										
TD3 2 mnth	0.214	**0.543**	1.000									
TD5 spot	0.765	0.646	0.318	1.000								
TD5 1 mnth	0.489	0.916	0.622	0.621	1.000							
TD5 2 mnth	0.147	0.608	0.872	0.293	**0.698**	1.000						
TD7 spot	0.614	0.456	0.087	0.775	0.420	0.035	1.000					
TD7 1 mnth	0.582	0.824	0.540	0.681	0.882	0.547	0.539	1.000				
TD7 2 mnth	0.154	0.538	0.739	0.252	0.585	0.850	0.078	**0.525**	1.000			
TC2 spot	0.353	0.563	0.477	0.473	0.646	0.562	0.278	0.613	0.494	1.000		
TC2 1 mnth	0.136	0.478	0.401	0.236	0.530	0.480	-0.035	0.236	0.174	0.366	1.000	
TC2 2mnth	0.130	0.461	0.373	0.257	0.513	0.471	-0.038	0.232	0.157	0.369	**0.955**	1.000

Correlation coefficients between the natural log of the spot, and natural log of lagged future prices are represented.

Table 2.2: Regression results, AR(3) with ex.var. "Jump".

	L.1	L.2	L.3	Const.	Hopp
TD3_1mnth.	0.1183	0.0199	-0.0184	0.0022	0.0794
(sd)	(0.025862)	(0.030098)	(0.032458)	(0.014491)	(0.059798)
P-value	**0.0000**	**0.5080**	**0.5710**	**0.8800**	**0.1840**
TD3_2mnth.	0.0703	0.0410	0.0232	0.0124	0.0052
SD	(0.026991)	(0.021902)	(0.0308)	(0.189671)	(0.01812)
P-value	**0.0090**	**0.0600**	**0.4510**	**0.9480**	**0.7760**
TD5_1mnth.	0.0853	0.0144	0.0005	0.0814	0.0012
SD	(0.026255)	(0.041693)	(0.02673)	(0.04267)	(0.010751)
P-value	**0.0010**	**0.7300**	**0.9860**	**0.0570**	**0.9090**
TD5_2mnth.	0.0672	0.0376	0.0281	0.0214	0.0040
SD	(0.02672)	(0.035802)	(0.03337)	(0.132567)	(0.011952)
P-value	**0.0120**	**0.2930**	**0.4000**	**0.8720**	**0.7370**
TD7_1mnth.	0.0745	0.0446	0.0200	0.0018	0.0004
SD	(0.028223)	(0.027239)	(0.03324)	(0.05343)	(0.010318)
P-value	**0.0080**	**0.1010**	**0.5470**	**0.9730**	**0.9700**
TD7_2mnth.	0.0077	0.0040	-0.0134	0.0040	0.0241
SD	(0.08158)	(0.144484)	(3.30923)	(0.144484)	(0.095163)
P-value	**0.9240**	**0.9780**	**0.9970**	**0.9780**	**0.8000**
TC2_1mnth	0.0127	0.0097	-0.0397	0.0289	0.0221
SD	(0.055789)	(0.06932)	(0.117562)	(0.720061)	(0.097087)
P-value	**0.8200**	**0.8880**	**0.7350**	**0.9680**	**0.8200**
TC2_2mnth	0.0077	0.0040	-0.0134	0.0040	0.0241
SD	(0.08158)	(0.144484)	(3.30923)	(0.144484)	(0.095163)
P-value	**0.9240**	**0.9780**	**0.9970**	**0.9780**	**0.8000**

The exogenous dummy "jump" is added to an AR (3) regression on the 1st difference of the squared values of the price series. For all series the coefficient is not found to be significant on a 5% level of significance, thus indicating that the jumps in the series do not affect the price series.

Table 3.0: Regression results of VECM expression 4.0

Variable	TD3_SF	TD3_SF2	TD5_SF	TD5_SF2	TD7_SF	TD7_SF2
_lns_td3						
L._ce1 | -	**-.02572077*** **	**-.0327096*** **				
LD.lns_td3 |	.36031872***	.3681255***				
L2D.lns_td3 |	-.03880515	-.05755849				
L3D.lns_td3 |	.05182718	.05291242				
L4D.lns_td3 |	.01314061	.00149576				
L5D.lns_td3 |	.03760502	.02803553				
L6D.lns_td3 |		-.0251179				
L7D.lns_td3 |		-.02700131				
LD.lnf_td3 |	.12847092***					
L2D.lnf_td3 |	.01202314					
L3D.lnf_td3 |	.03125779					
L4D.lnf_td3 |	.0573317					
L5D.lnf_td3 |	.05719582					
LD.lnf2_td3		.09775072***				
2D.lnf2_td3 |		.03982465				
3D.lnf2_td3 |		.0197959				
4D.lnf2_td3 |		.05747918*				
5D.lnf2_td3 |		.03490014				
6D.lnf2_td3 |		.04002226				
7D.lnf2_td3		.08742463***				
lnf_td3						
L._ce1 |	**-.0031034**					
LD.lns_td3 |	.05257552					
L2D.lns_td3 |	-.03088459					
L3D.lns_td3 |	-.01658731					
L4D.lns_td3 |	.01121324					
L5D.lns_td3 |	-.0173436					
LD.lnf_td3 |	.08899292**					
L2D.lnf_td3 |	.01286269					
L3D.lnf_td3 | -	-.00815319					
L4D.lnf_td3 |	.01002804					
L5D.lnf_td3 | -	-.01479629					
_lnf2_td3 |						
L._ce1 |		**.03233387** **				
LD.lns_td3 |		.14638757***				
L2D.lns_td3 |		-.04114751				
L3D.lns_td3 |		.02789728				
L4D.lns_td3 |		-.00614244				
L5D.lns_td3 |		-.0305824				
L6D.lns_td3 |		.06211139				
L7D.lns_td3 |		-.0381938				
LD.lnf2_td3 |		.02307352				
L2D.lnf2_td3 |		.01666644				
L3D.lnf2_td3 |		.00579548				
L4D.lnf2_td3 |		.01323503				
L5D.lnf2_td3 |		.02285029				
L6D.lnf2_td3 |		.02057348				
7D.lnf2_td3 |		-.0018559				
lns_td5 |						
L._ce1 |			**-.02458382*** **	**-.0372736*** **		
LD.lns_td5 |			.27279608***			

		.28383211***		
L2D.lns_td5 |	-.04593766	-.05004516		
L3D.lns_td5 |	.00553315	-.00871791		
L4D.lns_td5 |	.02970373	.06245806*		
L5D.lns_td5 |	.05866569*			
L6D.lns_td5 |	-.06599499*			
L7D.lns_td5 |	-.00056989			
L8D.lns_td5 |	-.05683519*			
LD.lnf_td5 |	.17381255***			
L2D.lnf_td5 |	.05973308			
L3D.lnf_td5 |	.07498115*			
L4D.lnf_td5 |	.02505968			
L5D.lnf_td5 |	.02473723			
L6D.lnf_td5 |	.07074591*			
L7D.lnf_td5 |	.07980493*			
L8D.lnf_td5 |	.06043892			
LD.lnf2_td5 |		.1484821***		
L2D.lnf2_td5 |		.06155329*		
L3D.lnf2_td5 |		.10774383***		
L4D.lnf2_td5 |		.01208159		
lnf_td5 |				
L._ce1 |	**-.00002758**			
LD.lns_td5 |	.08528933**			
L2D.lns_td5 |	-.03564171			
L3D.lns_td5 |	.00443633			
L4D.lns_td5 |	.02166014			
L5D.lns_td5 |	-.03623066			
L6D.lns_td5 |	.02613324			
L7D.lns_td5 |	-.02034579			
L8D.lns_td5 |	-.05376513*			
LD.lnf_td5 |	.05031782			
L2D.lnf_td5 |	.00813806			
L3D.lnf_td5 |	-.01425653			
L4D.lnf_td5 |	.02697887			
L5D.lnf_td5 |	-.00175201			
L6D.lnf_td5 |	-.04921223			
L7D.lnf_td5 |	-.01216531			
L8D.lnf_td5 |	.08680922**			
lnf2_td5 |				
L._ce1 |		**.02337719****		
LD.lns_td5 |		.18163587***		
L2D.lns_td5 |		-.0426058		
L3D.lns_td5 |		-.02020114		
L4D.lns_td5 |		.06417466*		
LD.lnf2_td5 |		-.0011136		
L2D.lnf2_td5 |		.0106394		
L3D.lnf2_td5 |		.01582105		
L4D.lnf2_td5 |		-.01424181		
lns_td7 |				
L._ce1 |			**-.0265665*****	**-.0470720*****
LD.lns_td7 |			.33283086***	.35027923***
L2D.lns_td7 |			-.04739497	-.04308002
L3D.lns_td7 |			.06693005*	.08909968**
L4D.lns_td7 |			.03795665	.04557297
L5D.lns_td7 |			.05113533	.08186489**

LD.lnf_td7 |					.1855524***	
L2D.lnf_td7 |					.12922084***	
L3D.lnf_td7 |					.03097348	
L4D.lnf_td7 |					-.05845305	
L5D.lnf_td7 |					.0357834	
LD.lnf2_td7 |						.12466769***
L2D.lnf2_td7 |						.09108895**
L3D.lnf2_td7 |						-.00543582
L4D.lnf2_td7 |						-.01808376
L5D.lnf2_td7 |						-.03245348
lnf_td7 |						
L._ce1 |					**-.00396258**	
LD.lns_td7 |					.09587377***	
L2D.lns_td7 |					-.00965392	
L3D.lns_td7 |					.00243857	
L4D.lns_td7 |					.00703429	
L5D.lns_td7 |					-.02057092	
LD.lnf_td7 |					.03350584	
L2D.lnf_td7 |					.01167291	
L3D.lnf_td7 |					-.00735234	
L4D.lnf_td7 |					.02097716	
L5D.lnf_td7 |					.06005094*	
lnf2_td7 |						
L._ce1 |						**.02269025****
LD.lns_td7 |						.13796501***
L2D.lns_td7 |						-.05013444
L3D.lns_td7 |						.05170143
L4D.lns_td7 |						.02183316
L5D.lns_td7 |						.02133054
LD.lnf2_td7 |						.07975197**
L2D.lnf2_td7 |						.0305227
L3D.lnf2_td7 |						-.04476535
L4D.lnf2_td7 |						-.03682776
L5D.lnf2_td7 |						-.02996182
Statistics						
aic	-9101.7184	-8717.6334	-10633.48	-10507.587	-11407.155	-11095.699
bic	-8986.838	-8561.0222	-10456.012	-10413.581	-11292.275	-10980.818

legend: * p<.05; ** p<.01; *** p<.001

Table containing coefficient from estimation of VECM, according to AIC. L is a lag operator, and D is the first difference operator.* Significantly different from zero on a 5% level of significance, ** significantly different from zero on a 1% level of significance, *** significantly different from zero on a 0,1% level. L denotes lagged value of variable; D denotes 1st difference of the series.

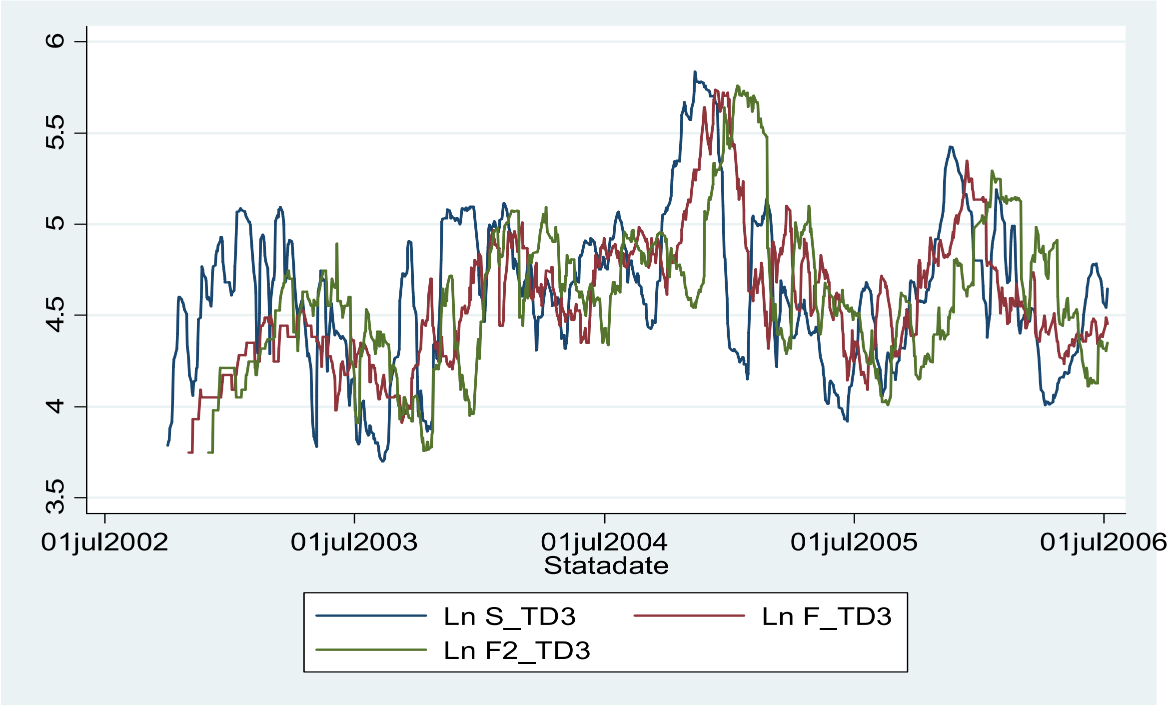


Figure 1.1: The graph shows the TD3 spot plus lagged values of the 1 and 2 month future rate

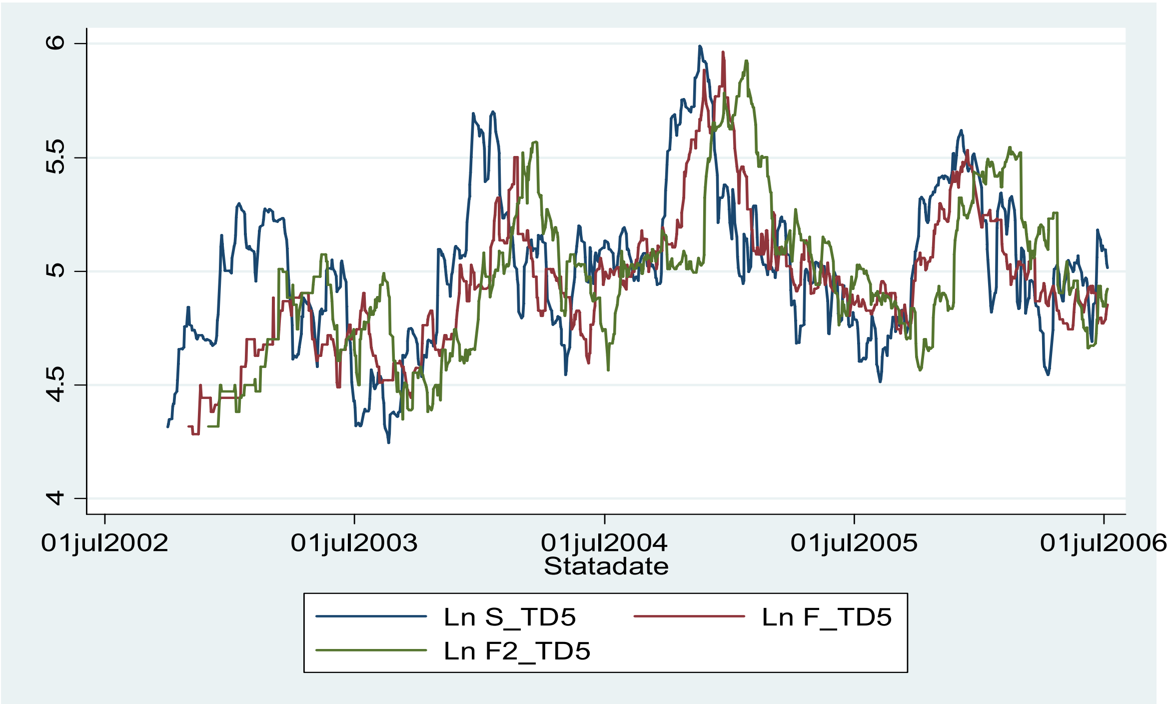


Figure 1.2: The graph shows the TD5 spot plus lagged values of the 1 and 2 month future rate.

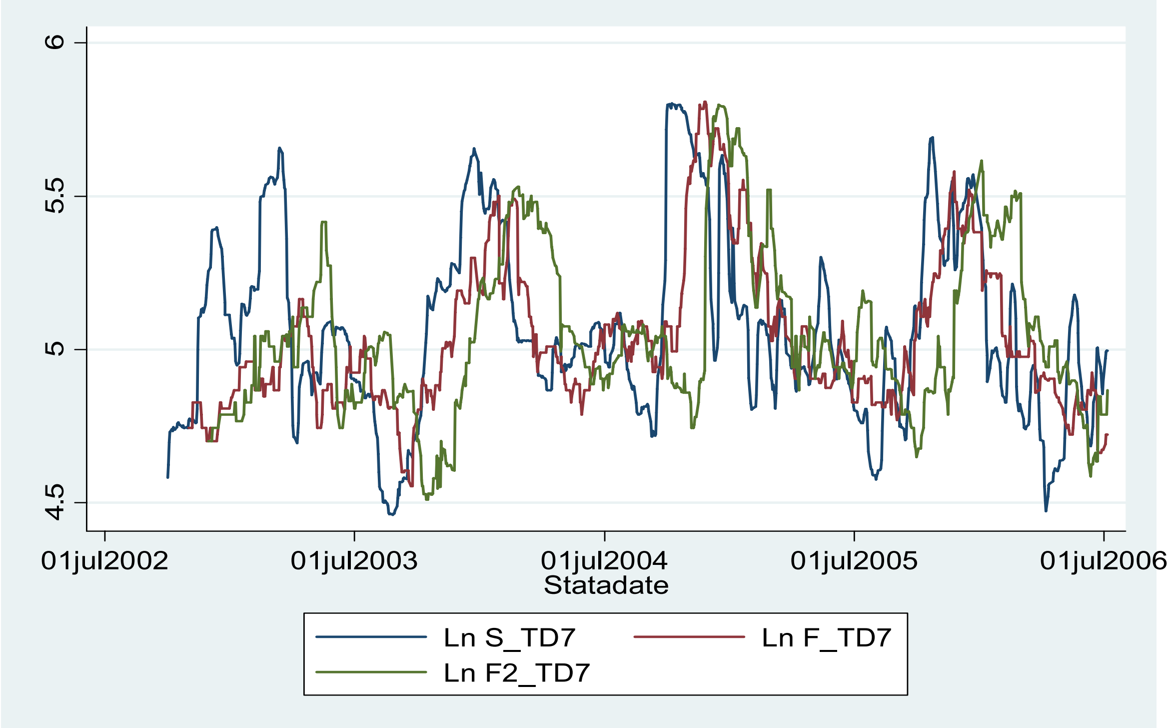


Figure 1.3: The graph shows the TD7 spot plus lagged values of the 1 and 2 month future rate

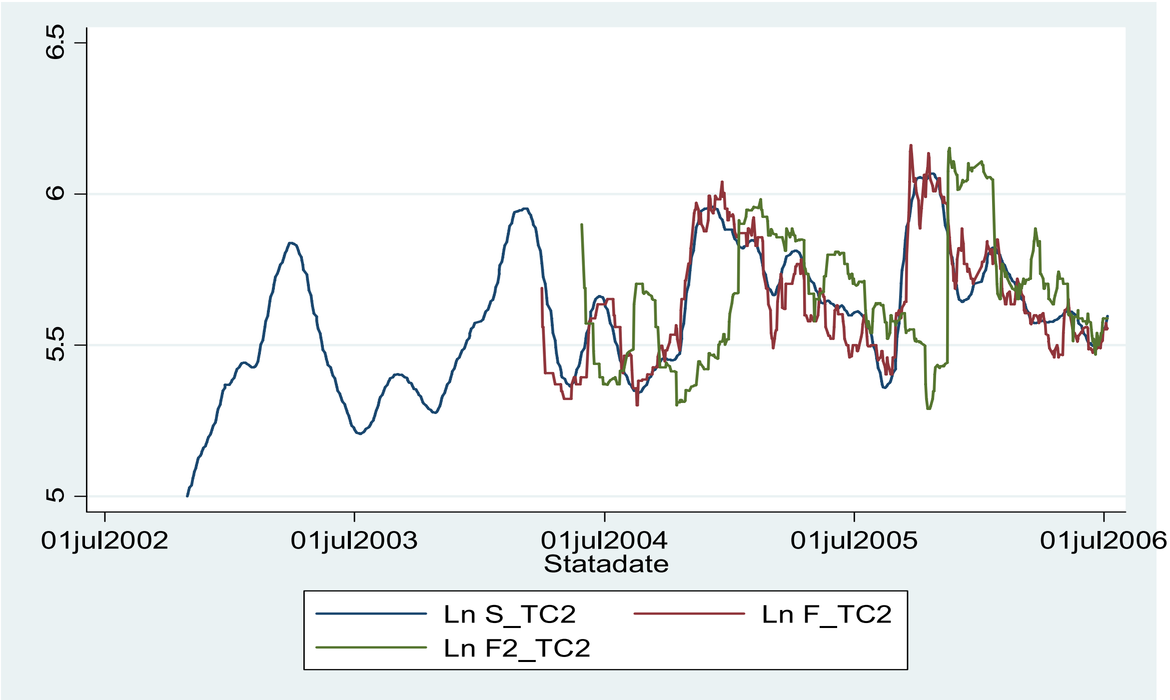
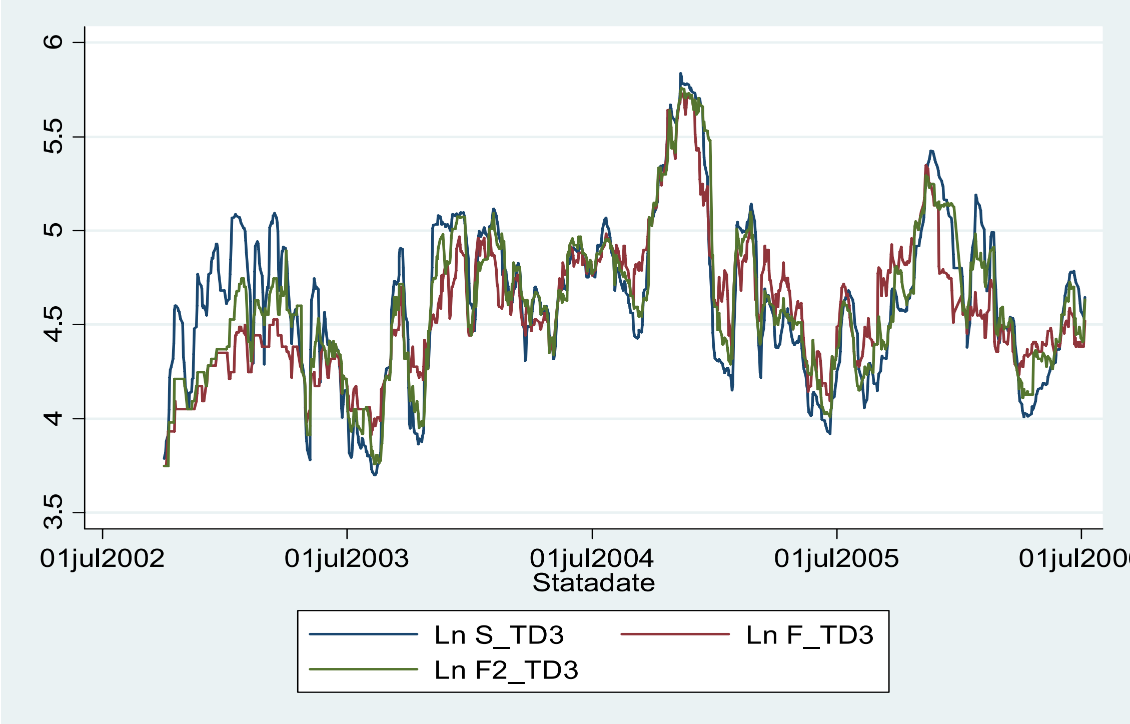
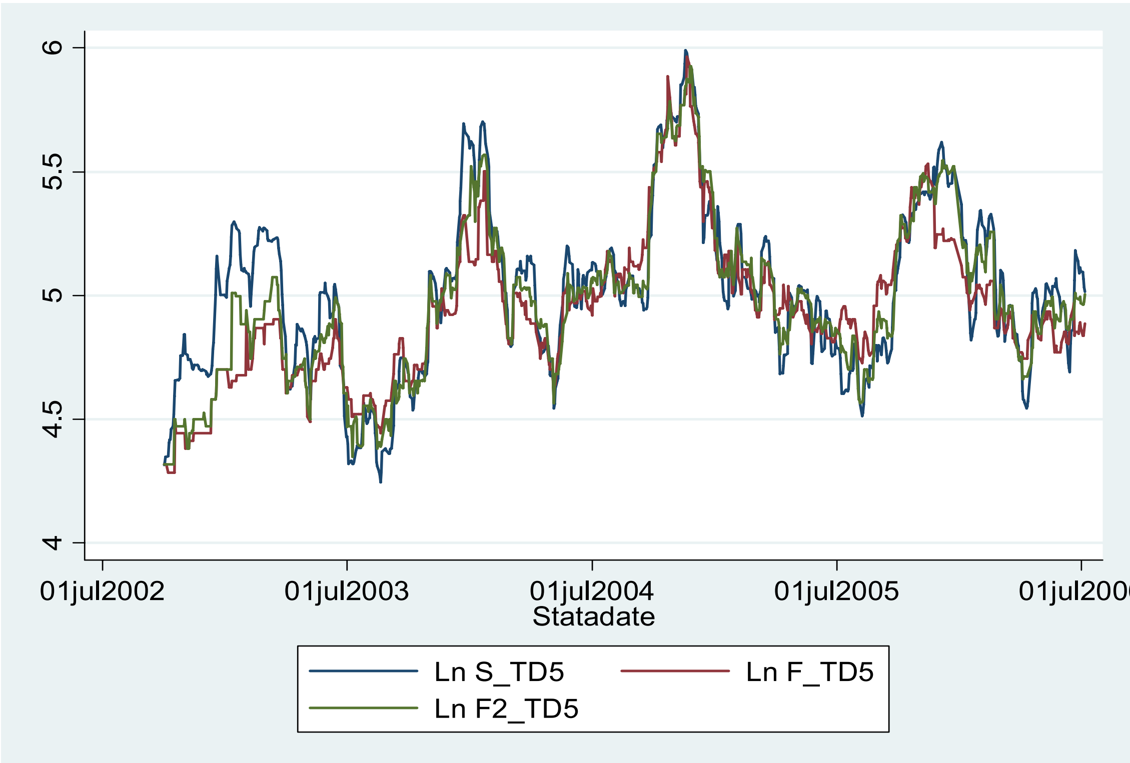


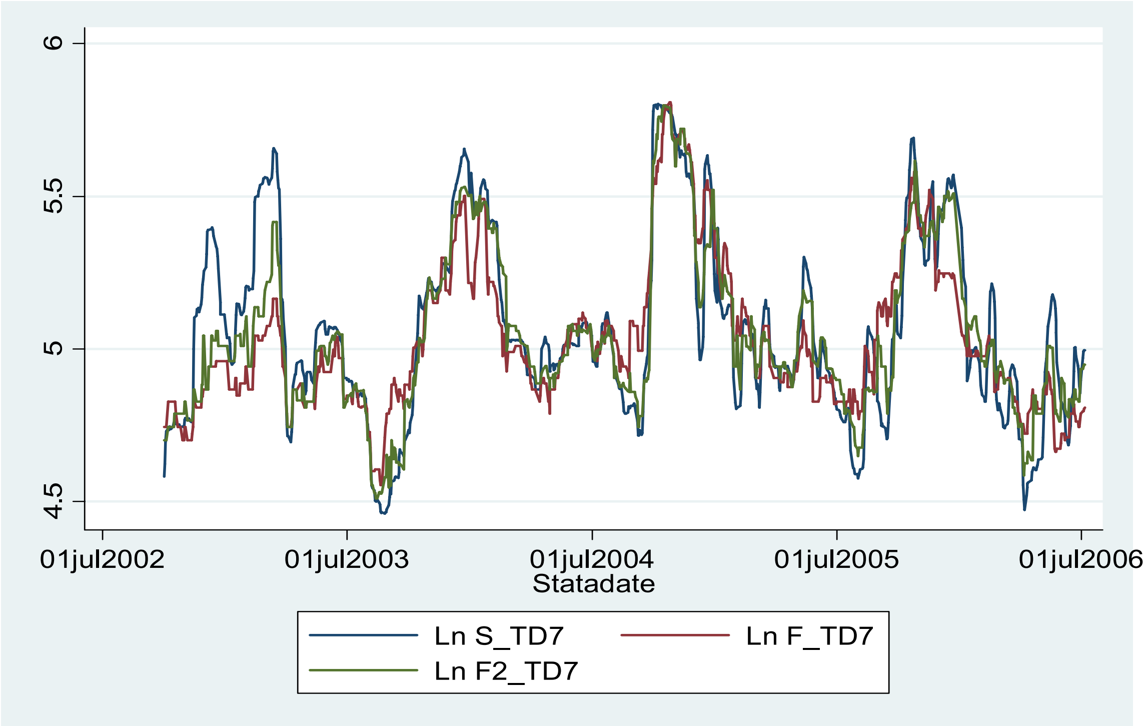
Figure 1.4: The graph shows the TC2 spot plus lagged values of the 1 and 2 month future rate.



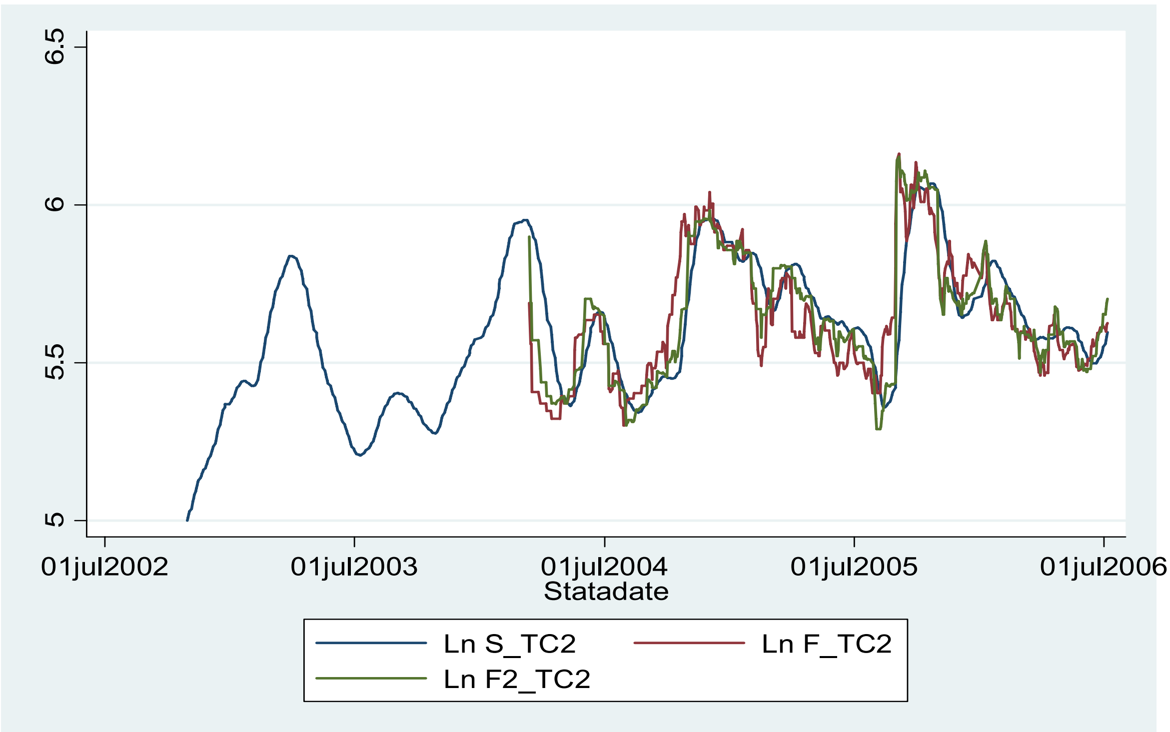
Figur 2.1: The graph showsTD3 Spot plus values of the 1 and 2 month future rate.



Figur 2.2: The graph showsTD5 Spot plus values of the 1 and 2 month future rate.



Figur 2.3: The graph showsTD7 Spot plus values of the 1 and 2 month future rate.



Figur 2.4: The graph showsTC2 Spot plus values of the 1 and 2 month future rate.